

## CHAPTER 2

### MAINTENANCE PROGRAM AND SAFETY CONSIDERATIONS

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#### 2-1. General

Mission readiness at Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) sites rests on the reliability of the electrical power supply and other site utilities systems. This reliability in turn rests on these systems being properly serviced and maintained.

*a. Maintenance planning.* Since maintenance work is generally done in the least time possible, maintenance activities should be planned. In addition to ensuring that the necessary materials, tools, parts are assembled and prepared for use in advance of the work, the maintenance activity plan should also cover all aspects of the activity which may include the following.

- (1) Scheduling with operations
- (2) Site access
- (3) Calibrated test equipment for each test required
- (4) Necessary lighting, electrical power, and service air to perform the work
- (5) Cleaning aids consisting of clean, white, lint-free cloths; solvents; vacuum cleaner; and dry compressed air
- (6) Personnel safety equipment required for the specific maintenance activities being performed

*b. Maintenance program.* A total maintenance program for C4ISR sites must contain elements of both preventive and predictive maintenance. Preventive maintenance is the systematic care and servicing of equipment and facilities to prolong their useful life. Predictive maintenance consists of the performance of periodic equipment inspections to identify and monitor symptoms (such as increasing wear, abnormal vibrations, or increasing power usage) which indicate that mechanical failure of a piece of equipment may be approaching. The goal of predictive maintenance is to develop an awareness of developing problems so that needed repairs can be made on a planned rather than on an emergency basis and unscheduled system down time resulting from unpredicted equipment failure is avoided. Effective execution of a total site maintenance program requires the implementation of the following elements.

(1) In general, people tend to concentrate their efforts on performing that work which is important to their supervisors. Therefore, successful implementation of an effective maintenance program for utility systems at any C4ISR site must be based upon the active interest, support, and involvement of the facility commander.

(2) Training and instruction of maintenance personnel, operators, and users of the particular equipment systems in proper operation, maintenance, and safety procedures

- (3) Systematic, periodic inspection and servicing of plant systems and equipment by skilled maintenance personnel
- (4) Assignment of specific maintenance responsibilities to skilled maintenance personnel and to operators of equipment
- (5) Continuing supervision of the site maintenance program
- (6) Periodic utility systems maintenance inspections to ensure the maintenance program is being implemented

## **2-2. Maintenance management**

The maintenance management approach required to ensure utility system reliability will vary from location to location depending upon the site location, mission, and number and complexity of site utility systems as well as other factors. The mechanics of implementation may also differ between locations with a small site using manual methods and a large facility requiring a computer to keep maintenance records and prepare maintenance reports. The approach to maintenance management for each site will have some basic requirements in common, regardless of the size or complexity of the equipment systems to be maintained. Appendix B provides recommended guidance for the implementation of each of the following basic requirements.

- a.* Definition of local equipment systems
- b.* Development of an appropriate maintenance records system
- c.* Development of an appropriate spare parts inventory control system
- d.* Vigorous implementation of the systems developed above

## **2-3. Maintenance training**

Standard training courses for utility system maintenance personnel are not available and apprenticeship training programs operated by local craft unions have been found not to be specific enough to directly satisfy facility operators' training needs. Typically, electric or public utilities either hire a journeyman craftsman in one of the crafts described above and then train him in the specific requirements of the job he is to perform, or hire untrained individuals with either a mechanical or an electrical aptitude and train them completely. The C4ISR utility systems operator will have similar options if new maintenance workers are needed. The Bureau of Apprenticeship and Training of the U. S. Department of Labor which has branch offices throughout the United States will develop site-specific apprenticeship training programs based on a job description provided by the facility operator. Development of these training programs is provided at no cost to the facility owner.

## **2-4. Basic maintenance procedures**

The following discussion describes basic maintenance procedures applicable to all types of site utility systems.

*a. Inspection.* Continuous inspection by plant personnel is necessary to detect and correct mechanical defects or conditions which prevent efficient operation. The following must be checked on a continuing basis.

(1) Each machine has a characteristic operating sound or appearance. A change from this normal sound or appearance requires the supervisor's immediate attention.

(2) Vibration is evidence of basic faults which should be corrected. Loose bearings may be either the cause or the result of vibration. Report all unusual vibration to the supervisor.

(3) Cleanliness is essential for trouble-free performance of mechanical and electrical equipment. Moisture, dirt, and oil cause deterioration of equipment systems.

(4) Conditions which cause excess heat must be eliminated.

(5) Couplings should be checked for misalignment. In cases of mechanical troubles, always check alignment. Misalignment may result in overheated and worn bearings or cause stresses which result in failure of the motor shaft.

(6) Electrical overload shortens the life of a motor and contributes to unreliable performance. Motors are designed for greater mechanical overloads than electrical overloads. The motor shaft, frame, and bearings can stand several times the rated load for long periods of time, but wiring will overheat when overloads as low as 15 to 25 percent are imposed continuously. Electrical overloads increase the temperature of the windings. The allowable temperature rise is usually stamped on the nameplate.

*b. Lubrication.* Lubrication is an important part of preventive maintenance. Proper lubrication prevents damage to wearing surfaces, reduces the maintenance required, and cuts power costs and equipment outages. Contaminants in lubricants produce wear and assist in the ultimate failure of the lubricated equipment.

(1) Use of the proper type of lubricant for the application is critical to successful maintenance results. Equipment manufacturer's detailed instructions should be consulted in all cases to ensure that the proper lubricant is being used.

(2) In order to avoid plant failures due to improper lubrication, the following lubricating precautions should be observed.

(a) Do not overlubricate. Overlubrication causes antifriction bearings to heat and may damage grease seals; it may also cause damage to the windings in electrical motors.

(b) Do not lubricate totally enclosed or insufficiently guarded equipment.

(c) Keep lubricant containers tightly closed, except when in use, to prevent contamination of the lubricant by the entrance of dust, grit, abrasives, and moisture. Lubricants should be stored in dust-free areas. Before using lubricant containers, the spouts and lips should be wiped; before using grease guns, the gun and fitting should be wiped to ensure the absence of foreign matter.

(3) The principal deteriorating elements in oil are dirt, water, oxidation, and excessive heat. If these are controlled, oil deterioration between lubrication periods is unlikely.

*c. Measuring operating temperatures.* Equipment cannot be maintained properly, unless limits of safe operating temperatures are known. Safe upper limits of operating temperatures are given by manufacturers and can be obtained on request. Use of touch to determine whether operating temperatures are under these maximum limits is unreliable, especially when operating temperatures are above 125°F. One of the following temperature measuring devices should be used instead.

(1) A hand type portable pyrometer, if available in the range required, provides a satisfactory method for measuring external surface temperatures of mechanical equipment.

(2) An ordinary mercury thermometer without a guard is satisfactory for measuring external surface or bearing temperatures. It should be calibrated for the range of use. Details of the use of a thermometer in each of these applications are as follows.

(a) To measure surface temperature, fasten the thermometer to the surface with adhesive tape with the bulb touching the surface. Use a 1/4 inch layer of glazier's putty to insulate the part of the bulb which does not touch the surface. Read only after indicated temperature has reached a constant value.

(b) To measure bearing temperatures, insert the bare thermometer bulb inside the inspection hole at the top of the bearing. Fit cardboard around the thermometer to cover the inspection hole. Read after a constant value has been reached.

*d. Painting.* Periodic painting is necessary to protect metal surfaces of equipment from corrosion. The required frequency of painting varies from 1 to 10 years, depending on the type of paint used, the method of application, and the conditions of wear. Always paint metal surfaces before corrosion becomes so severe that equipment is damaged. Surfaces must be prepared before they can be painted; sandblast metal surfaces if practical or clean them thoroughly with sandpaper and a wire brush. Paint should be mixed properly and screened, if necessary, to remove grit and film. Paint containers should be covered when not in use. Brushes, rollers, and spray applicators should be cleaned before and after use.

*e. Maintenance tools.* An adequate supply of tools is essential to efficient conduct of a site utility system maintenance program. The number and type of tools required will vary depending on the types of utilities systems present at the site. See appendix C for a list of commonly required basic and trade tools.

## **2-5. General safety considerations**

This section describes basic safety concepts and practices which are applicable to the maintenance of all utility systems at C4ISR sites. It is intended that these concepts and practices form the basis for the development, by C4ISR maintenance and safety personnel, of a detailed and comprehensive site-specific maintenance safety program for each C4ISR site. Additional assistance in this effort may be obtained by contacting the local chapter of the National Safety Council. Specific manufacturer's equipment manuals should also be consulted when servicing the equipment, as additional safety procedures not mentioned here may be required.

*a. Lighting.* Good lighting is very important and is required to avoid injuries due to tripping or slipping. Ensure that adequate lighting is provided throughout the facility and that failed light bulbs are replaced on a regular basis.

*b. Housekeeping.* Good housekeeping and clean equipment areas will reduce hazards. Keep the plant area and equipment clean and free of unnecessary clutter. Keep the floors dry and clean to reduce slipping hazards.

*c. Practical jokes.* Do not participate in horseplay or practical jokes at any time while onsite. Activities such as tripping, shoving, pushing, scuffling, acrobatics, or pulling chairs from under people, can often lead to serious accidents and personal injury.

*d. Manual lifting.* Always employ safe lifting techniques when manually lifting loads. Do not lift objects that are too heavy for one person without help. Lift heavy objects with the leg muscles rather than the back muscles. Squat close to the load to be lifted, keep the back and shoulders straight, distribute the weight equally on both legs, and lift evenly. Make certain the body is not twisted, but rather the whole body is turned by shifting the feet when turning to place an object to the side.

*e. Preventive maintenance.* A vigorous program of preventive maintenance throughout the facility will have a positive effect on the overall safety program by assuring that all of the safety considerations designed into site equipment remain functional.

*f. Attitude.* Be safety conscious. Do not enter enclosures marked "High Voltage," and report all defects, malpractices, and safety hazards to supervision.

*g. Safety training.* A comprehensive safety training program should be developed at each site for site maintenance personnel. Though the content of this program may vary from site to site, each site program as a minimum, should cover the type of material discussed in this manual, the use of individual protective equipment, and electrical safety. The local chapter of the National Safety Council should be contacted regarding additional safety training needs, and prepared training programs and materials.

## **2-6. Fire safety**

In the event of a fire, call the fire department immediately; then, attempt to extinguish the fire with portable equipment.

*a. Smoking.* Smoke only in designated areas.

*b. Combustible materials.* Rags and combustibles should be stored in covered fireproof containers, in approved storage areas. Keep fire and open flames away from hazardous or flammable material storage areas.

*c. Fire extinguishers.* Always be prepared for the possibility of a fire. Ensure an adequate number of the proper type of fire extinguishers are available throughout the facility.

(1) Fire extinguishers should be selected to be compatible with the class of fire considered to be possible in the area where the extinguisher is to be located. Water should not be used on electrical or petroleum-based fires. Fire classifications are as follows.

(a) Class A - Fires in ordinary combustible materials

(b) Class B - Fires in flammable liquids

(c) Class C - Electrical fires

(2) Fire extinguishers must be inspected regularly, and tagged to show they are full and have been

inspected. After each use, the fire extinguishers must be refilled for the next emergency. Personnel must be trained to know the location of area fire extinguishers and how to use them properly. Do not allow CO<sub>2</sub> extinguisher discharge to contact the skin due to the danger of "frost bite" from "dry ice" discharge. The use of an extinguisher in a confined space such as a room may cause suffocation due to lack of oxygen resulting from filling the space with carbon dioxide.

## 2-7. Maintenance safety

An effective safety program includes the establishment of controls and procedures designed to protect the health and welfare of maintenance personnel. Key elements of such a program are described below.

*a. Permit program.* Performance of required maintenance or repairs will sometimes require performing actions which are normally prohibited within a facility. With regard to C4ISR facilities, the most obvious examples of such actions are the use of welding and cutting or burning equipment in a potentially flammable area and personnel entry into vessels for purposes of inspection or internal repairs. Where such actions cannot be avoided from an operational standpoint, special care must be taken to allow performance of these actions with maximum safety. A proven technique for assurance that hazardous maintenance functions are performed with maximum safety is the use of a permit system.

(1) Under a permit system, a special permit is required before specified types of maintenance work can be implemented. The permit specifies the type of work to be performed, the location of the work, the start time of the permit, the time the permit is to expire, and any special safety precautions to be taken prior to or during the performance of the work. The permit is initiated by the operating department and accepted by the maintenance department. It should be signed by the operations department manager after he has visited the area where the work is to be done. His signature is evidence that he has visited the site of the work, and as a responsible individual, has verified that all required precautionary safety measures have been taken and that the work may proceed. The permit would then be signed by the maintenance manager as evidence that he, as representative of the maintenance department, has also visited the work site and agrees that it is safe for the work to proceed. The work may then proceed until the time of expiration of the permit. Normally all such permits would be voided in the event of a fire or other site emergency, and would not be considered for reissue until the emergency was over. At least two basic types of permits should be used at the C4ISR sites with others added to the system as operating experience requires. These are for hot work (welding, cutting, open flame) and vessel entry.

(2) Among the precautions which should be taken prior to issuance of a hot work permit are the following.

- (a) The equipment has been emptied and cleaned of all flammable material.
- (b) Test for the presence of combustible vapors.
- (c) Flammables in the surrounding area should be removed or protected from the effects of the hot work.
- (d) Assignment of a "fire watch" during and following the work to verify that no unnoticed or slow-burning fires have been started by the work.

(3) Precautions to be taken prior to issuance of a vessel entry permit include the following:

- (a) Emptying and cleaning the vessel of its contents to the maximum extent possible.

- (b) Blinding all openings from which materials could flow into the vessel.
- (c) Providing adequate positive ventilation for the vessel.
- (d) Locking out all equipment installed on the vessel.
- (e) Sampling tank atmosphere to determine the presence of toxic vapors or an oxygen deficient atmosphere.
- (f) Providing adequate safety equipment for the man entering the vessel which could include life lines and oxygen supply equipment.
- (g) Assigning an individual at the bin entrance whose duty is to watch the workers inside the vessel and aid them in exiting the vessel should trouble occur.

*b. Lockout/tagging program.* Prior to removal of any protective guards or covers from any moving machinery preparatory to performing maintenance on the equipment, the machine must be locked out of service. Locking out a piece of equipment is accomplished by turning the handle on the main circuit breaker of the equipment's main power (not control) circuit to the open position and locking it in place by padlocking. Where more than one craft (e.g., machinists and electricians) are involved in the repair of a piece of equipment, each craft should have its own separate padlock to lock the equipment out of service. After all padlocks are in place, an attempt should be made to start the locked out equipment to verify that it has, in fact, been locked out. The person from each craft actually servicing the locked out equipment should hold the key to his craft's padlock. As each craft completes its planned maintenance work on the locked-out equipment, it removes its padlock. When all padlocks have been removed, the equipment is ready to be returned to service.

*c. Maintenance access.* Maintenance personnel must be aware of areas within the facility with special access requirements and follow the rules associated with those areas while carrying out maintenance activities. Some facilities have areas which one person may not enter alone. Some facilities refer to these as "No-Lone" or "Buddy" areas. These areas are typically not visited routinely, so it could be a long time before someone working alone in the area who had an accident would be discovered. In addition to entry by a team, a notification to area supervision of entry time and estimated duration of work is usually required, along with notification to supervision when the team leaves the area.

*d. Safety equipment.* Personnel performing maintenance on site utility systems should use the following personal safety equipment. This listing describes safety equipment required to perform routine maintenance for a facility and facility systems operating in a non-emergency condition. A description of the protective equipment and isolation and decontamination procedures for working in contaminated areas is beyond the scope of this manual.

- (1) Long-sleeve coveralls (100% cotton)
- (2) Safety shoes
- (3) Safety glasses
- (4) Gloves

- (5) Flashlight
- (6) Non-conducting hard hat
- (7) Hearing protection in high noise areas
- (8) Respiratory protection as required by site conditions

(9) When making initial openings into systems which are or recently have been under pressure, a full face shield and rain suit are required.

(10) Additional maintenance safety equipment should be available at the site for use in performing larger scheduled maintenance projects. Such equipment may include safety harnesses, ropes, ladders, gas masks, welding safety equipment, safety lamps, toxic gas and oxygen-deficiency indicators, and explosimeters.

*e. Safe work practices.* The following is a listing of safe work practices which apply primarily to the maintenance of mechanical systems. Special practices to be observed in working with electrical equipment are described in paragraph 2-8.

- (1) Keep tools clean and properly stored.
- (2) Remove items of clothing and jewelry such as ties, rings, wristwatches, and neck chains which could be caught in equipment being inspected or serviced.
- (3) Do not bypass any alarm or safety system, unless maintenance instructions specifically call for such actions.
- (4) Do not operate switches, push buttons, or any disconnect when equipment or circuits are tagged or locked out.
- (5) Do not wipe down or attempt to service equipment in motion or in the vicinity of moving parts.
- (6) Always ensure that guards are in place before operating equipment. Report missing guards to supervisors.
- (7) Provide for periodic independent inspections by qualified inspectors for boilers, personnel elevators, and other such equipment.
- (8) Provide for continuing maintenance and periodic proof testing of mechanical lifting equipment and slings.
- (9) Avoid angled lifts when using mobile cranes or overhead crane systems.
- (10) Follow the abrasive product manufacturer's recommendations with regard to the storage, handling, mounting, and use of abrasive grinding wheels.
- (11) Weld only where there is adequate ventilation and the area is free of combustible material. Make sure the equipment used is in good condition and in the case of electric arc welding, make sure that both the welder and the work being welded are adequately grounded. Wear proper protective clothing and



adequate specialized eye protection. Do not weld galvanized or other coated metals without taking the correct precautions.

(12) Do not use compressed air for cleaning clothing or equipment and never point a stream of compressed air at a coworker.

(13) Wear protective clothing and personal protective equipment when working with hazardous chemicals.

## **2-8. Electrical safety**

Any work done on or near electrical equipment of any kind should be considered dangerous and proper safety precautions must be taken. Personnel performing such work must be familiar with and observe all safety precautions. The basic safety rules to follow when dealing with electrical system equipment are as follows.

*a. Electrical equipment.* Consider all electrical equipment to be energized until it is known positively to be de-energized. Further, even after de-energization of electrical equipment, voltages may still exist and these voltages may be sufficient to cause death. Therefore, voltage tests should be performed and the voltages dissipated before proceeding with planned maintenance work.

*b. Electrical work.* Work to be done on energized lines and equipment must be done only by personnel qualified for that voltage classification. All tools and equipment used in such work must be maintained in proper operating order and should be periodically tested for compliance with all safety requirements.

*c. Equipment-specific requirements.* Technical manuals furnished with electrical equipment/systems should be consulted for specific safety requirements.

*d. Safety watch.* All maintenance should be performed with a minimum of one individual on a standby basis to react to an emergency situation should one occur.

*e. Emergency lighting.* Emergency lighting should be installed and maintained in equipment areas.

*f. Safety board.* A safety board with the following equipment should be located in a convenient location near electrical equipment to be serviced.

- (1) Telephone with emergency numbers indicated
- (2) First aid kit
- (3) Flashlight
- (4) Fire extinguisher
- (5) Insulated hook stick
- (6) Grounding cables
- (7) Insulating blankets

- (8) Insulating gloves
- (9) Spill containment materials
- (10) Hazardous gas analyzer (manhole testing)
- (11) Rubber gloves
- (12) Rubber apron
- (13) Safety goggles
- (14) Face protection
- (15) Rubber mat